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# PULSED ACOUSTIC VORTEX SENSING SYSTEM
## Volume III:  PAVSS Operation
## and Software Documentation

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Systems Division
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Wilmington, MA 01887

JUNE 1977

FINAL REPORT

Prepared for
## U.S. DEPARTMENT OF TRANSPORTATION
### FEDERAL AVIATION ADMINISTRATION
Systems Research and Development Service
Washington DC    20591

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16. Abstract

Avco Corporation's Systems Division designed and developed an engineered Pulsed Acoustic Vortex Sensing System (PAVSS). This system is capable of real-time detection, tracking, recording, and graphic display of aircraft trailing vortices.

This volume of the report presents the operation of the pulsed acoustic vortex sensing system and the computer software documentation.

Other volumes of this final report are as follows:
    Volume I      Hardware Design
    Volume II     Studies of Improved PAVSS Processing Techniques
    Volume IV     PAVSS Program Summary and Recommendations

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## PREFACE

The problems related to aircraft trailing vortices are currently under intensive study for the Federal Aviation Administration (FAA) by the U. S. Department of Transportation. The Transportation Systems Center (TSC) of the U. S. Department of Transportation (DOT) initiated and is carrying out several programs in this area, including programs to develop acoustic systems for detecting, tracking, and measuring the strength of aircraft wake vortices. The system described in this report was designed, built, and tested by Avco Corporation's Systems Division (Avco/SD) for DOT/TSC under Contract DOT-TSC-620, dated 15 August 1973. It is an engineered extension of the pulsed acoustic multi-static radar concept developed by the Communications Branch of DOT/TSC at Cambridge, Massachusetts.

The Avco-engineered system is designed to permit simultaneous operation of two (of three) 8-element arrays deployed along an appropriate baseline, and to provide real-time detection, tracking, recording, and graphic display of vortex locations.

This volume of the final report describes operation of the system and documents the software. Other aspects of the system are covered in additional volumes (I, II, and IV).

The work performed under this contract was significantly enhanced by the close cooperation and contributions of Ralph Kodis, David Burnham, and Thomas Sullivan, all of DOT/TSC.

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# METRIC CONVERSION FACTORS

## Approximate Conversions to Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|--------|---------------|-------------|---------|--------|
| | | **LENGTH** | | |
| in | inches | 2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| | | **AREA** | | |
| in² | square inches | 6.5 | square centimeters | cm² |
| ft² | square feet | 0.09 | square meters | m² |
| yd² | square yards | 0.8 | square meters | m² |
| mi² | square miles | 2.6 | square kilometers | km² |
| | acres | 0.4 | hectares | ha |
| | | **MASS (weight)** | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| | | **VOLUME** | | |
| tsp | teaspoons | 5 | milliliters | ml |
| Tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| ft³ | cubic feet | 0.03 | cubic meters | m³ |
| yd³ | cubic yards | 0.76 | cubic meters | m³ |
| | | **TEMPERATURE (exact)** | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

## Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|--------|---------------|-------------|---------|--------|
| | | **LENGTH** | | |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| m | meters | 1.1 | yards | yd |
| km | kilometers | 0.6 | miles | mi |
| | | **AREA** | | |
| cm² | square centimeters | 0.16 | square inches | in² |
| m² | square meters | 1.2 | square yards | yd² |
| km² | square kilometers | 0.4 | square miles | mi² |
| ha | hectares (10,000 m²) | 2.5 | acres | |
| | | **MASS (weight)** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1000 kg) | 1.1 | short tons | |
| | | **VOLUME** | | |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons | gal |
| m³ | cubic meters | 35 | cubic feet | ft³ |
| m³ | cubic meters | 1.3 | cubic yards | yd³ |
| | | **TEMPERATURE (exact)** | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |

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# 1. INTRODUCTION

This introduction is presented in two parts. Paragraph 1.1 serves as an introduction to the complete final report; Paragraph 1.2 serves as an introduction to this volume (Volume III) of that report.

## 1.1 INTRODUCTION TO THE FINAL REPORT

Trailing vortices from heavy jet aircraft represent a currently undefined hazard, particularly during landing and takeoff operations. Considerations of safety and the need to optimize airport operation make it essential to acquire positive information about the presence and locations of vortices generated by heavy aircraft.

The feasibility of using multi-static pulsed acoustic radar to detect and track wake vortices has been demonstrated by the U. S. Department of Transportation's Transportation Systems Center (DOT/TSC) in tests of Logan International Airport, Boston, Mass.; at John F. Kennedy International Airport, New York, N.Y.; and at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, N. J. The hardware used during these test consisted of laboratory models. The equipment was not engineered for long-term installation in the field, and was incapable of automatic real-time data processing and display.

This report describes a pulsed acoustic vortex sensing system (PAVSS) development program carried out by Avco Systems Division (Avco/SD) for DOT/TSC under Contract DOT-TSC-620. The goal of this program was to develop, build, and test an engineered wake vortex sensing system consisting of acoustic sensors and associated electronics; to acquire and process the sensed data; and to display this data visually in real time.

The complete final report on this program consists of this volume (Volume III, PAVSS OPERATION AND SOFTWARE DOCUMENTATION) and three additional volumes, as follows:

Volume I        HARDWARE DESIGN

|  |  |
|---|---|
| Volume II | STUDIES OF IMPROVED PAVSS PROCESSING TECHNIQUES |
| Volume IV | PAVSS PROGRAM SUMMARY AND RECOMMENDATIONS |

## 1.2 INTRODUCTION TO VOLUME III, PAVSS OPERATION AND SOFTWARE DOCUMENTATION

This volume of the final report on the pulsed acoustic vortex sensing system describes the operating procedures and documents the software. The program magnetic tapes were furnished with the hardware. The program listings, which form part of this volume, are furnished under separate cover.

### a. Background

Avco/SD designed and developed a PAVSS capable of detecting and locating trailing (wake) vortices produced by aircraft during landings. The system generates, transmits, receives, and processes acoustic pulses in real time. Vortex position plots and diagnostic displays are also generated in real time. Both a cathode ray tube (CRT) terminal and a hard-copy printer are available for displaying data and diagnostic information. Operation of the hardware system and a description of the software used to control system operation and to process data are covered in this volume of the final report.

### b. Organization of Volume III

The remaining sections of this volume of the final report cover the areas indicated below:

Section 2  Describes Operation of the PAVSS

Section 3  Documents the PAVSS Software

## 2.  SYSTEM OPERATION

### 2.1  SYSTEM DESCRIPTION

This section provides the operator with an over-view of the PAVSS
to aid his understanding of where certain operations are carried
out and the consequences of various operations.

#### 2.1.1  System
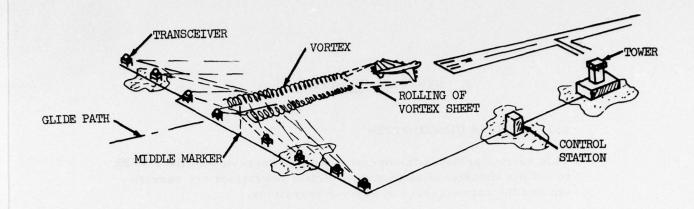
From a hardware standpoint, the PAVSS consists of a pulsed
acoustic radar subsystem (with up to 24 acoustic antennas), a
data acquisition subsystem (which includes a minicomputer), a
data display subsystem, and a data storage subsystem.  The
arrangement (for a single antenna array) is shown in conceptual
and block diagram form in Figure 2-1.  Up to three antenna
arrays can be deployed, but only two can be operated simulta-
neously by the system.  The operator is primarily concerned
with the equipment located in the  control station (equipment
trailer).  The hardware items located there are often referred
to as the housed equipment as distinct from the field equipment
which consists generally of those hardware items deployed
external to the control station.

#### 2.1.2  Housed Equipment
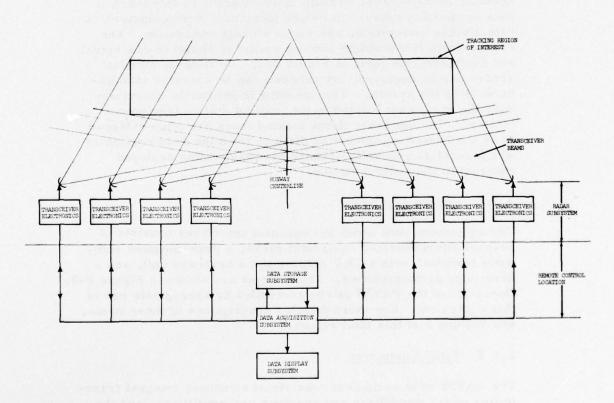
The equipment with which the operator interfaces consists of
several interconnected equipment racks, a desk-mounted com-
puter terminal with a CRT display and a keyboard unit, and a
hard-copy printer/plotter.  These items are shown in Figure 2-2.
Operation of the PAVSS can be controlled by appropriate use of
this equipment.  For more detailed descriptions of these items,
see Volume I of this final report.

#### 2.1.3  Field Equipment

The PAVSS field equipment consists of antennas, integral trans-
mitter power amplifiers and receiver pre-amplifiers, and the
cabling used to connect the antenna arrays to the control station.
Knowledge of the exact antenna spacings in terms of distance

(a) Artist's Concept



(b) Block Diagram

FIGURE 2-1   PAVSS Configuration:  (a) Artist's Concept,
(b) Block Diagram

FIGURE 2-2   PAVSS Operator Terminal (23250A)

from the runway centerline is required for system data entries. For further, more detailed descriptions of the field equipment, see Volume I of this final report.

### 2.1.4  Display Formats

Several display formats are available for CRT and hard-copy data display. These are operator selectable for viewing either in real time or in a playback viewing mode.

### 2.1.4.1  CRT Displays

Table 2-1 lists the CRT displays of PAVSS data that are available during real time or playback mode operation.

### 2.1.4.2  Hard-Copy Displays

Several hard-copy displays are available. They are listed on Table 2-2.

### 2.1.5  Data Storage

The system contains two magnetic tape recorders -- one analog, the other digital -- for data storage and handling.

The analog recorder is a 14-track unit that uses 1-inch tape. Raw analog data is recorded on this machine for subsequent off-line processing when desired.

The digital recorder is a 7-track unit used to perform two functions:  (1) to enter software programs into the PAVSS, and (2) to record, in either real time or in playback mode, vortex solution data as required by the PAVSS.

### 2.2  OPERATING PROCEDURES

Operation of the PAVSS requires that a specific procedure be followed. Since the system is under computer control, the input parameter limits must be strictly adhered to, and the sequences of operation must be followed precisely or the system will halt or malfunction. Paragraphs 2.2.1, 2.2.2, and 2.3 (Program Loading, Data Collection, and SYSTEM OPERATING MODES,

## TABLE 2-1   CRT Displays

| | Display Title | Reference Figure | Description |
|---|---|---|---|
| 1. | Plot (P) | 2-3 | This display consists of a single page on which the height of each vortex is plotted versus time and the horizontal position of both vortices is plotted versus time. The header data contains pertinent run identification information, including array identification, run number, aircraft identification (ID), start-of-run (SOR) time, and mode. The time scales--which are in seconds and can be 60, 120, or 180 seconds--are keyboard selectable by the operator. |
| 2. | Cross Plot (C) | 2-4 | This plot contains two grid presentations. The upper half of the display plots both vortices from one array in terms of horizontal distance versus elapsed time. The lower display plots both vortices from one array in terms of horizontal distance versus vertical height. This display includes the same header data as the Plot (P) display. |
| 3. | Processing Parameters | 2-5 | This display shows either page 1 or page 2 of the current processing parameters. The first page contains the operating mode and tracker parameters and some of the header input data. The top of the page gives the number of the next run and the last wind calculation up-date for the two arrays currently operating in real time. Page 2 contains the antenna geometries and the data mask-out regions. |
| 4. | Acoustogram Plot (A) | 2-6 | This display shows the acoustic data received by the selected receiver. The horizontal scale is in time (in terms of milliseconds from the transmit pulse). The vertical scale is in terms of frame number after the start-of-run. The horizontal broken line shown at frame 175 on Figure 2-6 denotes the mask-out region, with the solid portions of the line representing those time zones during which no data is allowed to enter the vortex processor. |
| 5. | Tracking Acoustogram (T) | 2-7 | This display is the same as the acoustogram plot (A) described in 4., above, except that only the tracked data is displayed. |
| 6. | Dot Grid | 2-8 | Each of the above CRT displays (A, T) includes a dot grid in the lower right-hand corner. This is shown, in enlarged form, on Figure 2-8a. This grid identifies those trackers currently tracking data. If the data is insufficient and cannot satisfy the tracker minimum requirements, a low-intensity spot will appear at the appropriate grid location. When there is sufficient data and the tracker is tracking, the appropriate spot increases in intensity. Figure 2-8b shows the layout of the dot grid. Each array has six active transceivers. Each receiver can receive a maximum of three line-of-sight (LOS) and three vortex returns. These have their origin in specific transmitters on the other side of the array. Therefore, the upper left dot is receiver 1's response to transmitter 4 and the lower right dot is the response of receiver 6 to transmitter 3. The four sets, or blocks, of grids represent the 2 LOS and 2 vortex returns for the two arrays as indicated in Figure 2-8b. |
| 7. | Digital Tape Displays | 2-9 | The header and vortex location data recorded on digital tape may be displayed in playback mode operation on the CRT. A typical display is shown in Figure 2-9. Either manual page-by-page or automatic page-turning display is possible. The data displayed on the first page is the header date (Figure 2-9a). It presents all pertinent data for the run being covered. Subsequent records in the file contain the vortex location data, as shown in Figure 2-9b. |
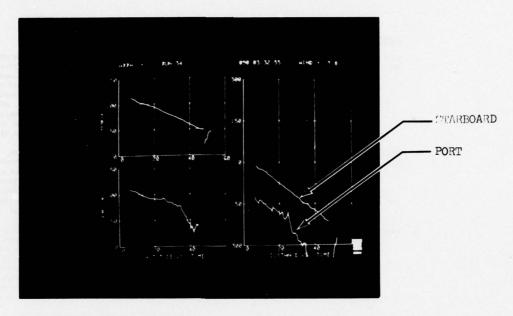
FIGURE 2-3    Plot (P), CRT Display
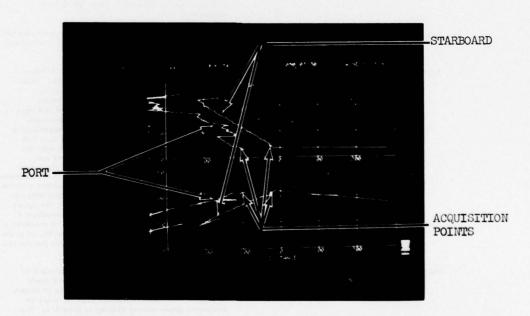


FIGURE 2-4    Cross Plot (C), CRT Display
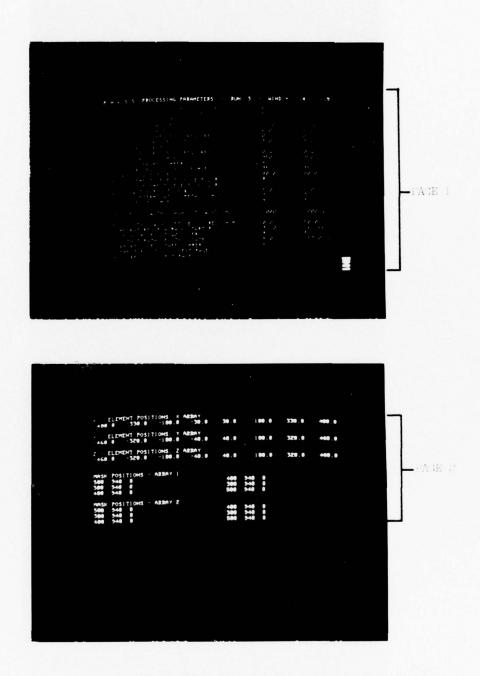
FIGURE 2-5   Processing Parameters, CRT Display

MASK
REGIONS
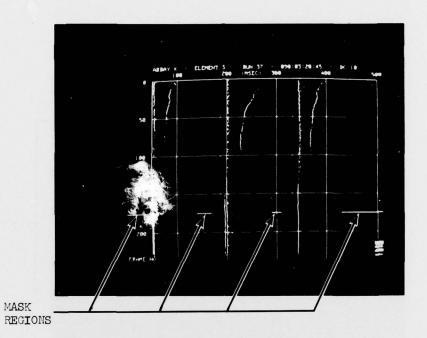
FIGURE 2-6   Acoustogram Plot (A), CRT Display



MASK
POSITIONS
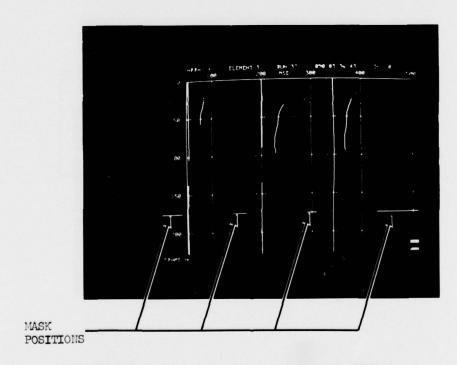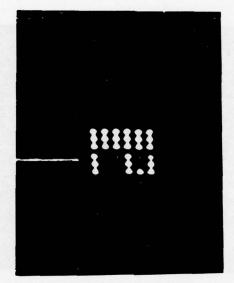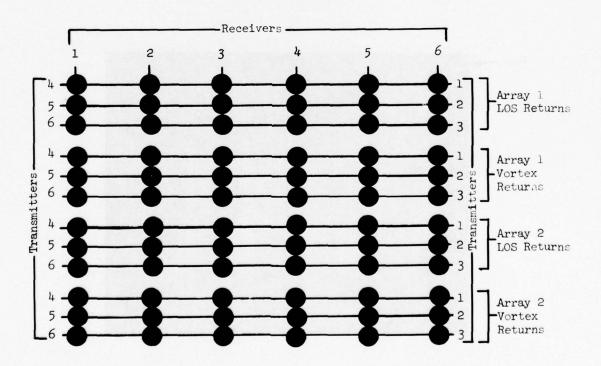
FIGURE 2-7   Tracking Acoustogram (T), CRT Display

(a)   Photograph of Display
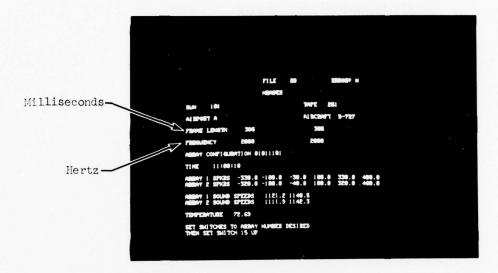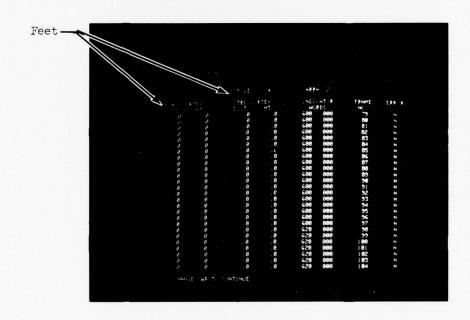


(b)   Tracker Indicator Layouts

FIGURE 2-8   Dot Grid, CRT Display:  (a) Photograph of Display,
(b) Tracker Indicator Layouts

(a) Header Page



(b) Data Page

FIGURE 2-9   Digital Tape, CRT Display:  (a) Header Page,
(b) Data Page

## TABLE 2-2    Hard-Copy Displays

| | Display Title | Reference Figure | Description |
|---|---|---|---|
| 1. | Processing Parameters | 2-10 | Upon appropriate command, the hard-copy printer will print out all of the processing parameters currently entered in the machine. During printout, all other system functions halt until the printout is completed. |
| 2. | Plot (P) | 2-11, 2-12 | Plot (P) Printout.  The plot (P) printout is the same as the Plot (P) CRT display.  The header data is the same as the CRT display except that the time scale is included and the start-of-run time is entered at the end of the plot.  The total time scale of the CRT plot (P) display is limited to the input on Line A Column 2 of the processing parameters.  The hard-copy time scale changes with this entry, but the printout continues until the run is stopped. Figure 2-12 shows the hard-copy display of both arrays on the same grid. |
| 3. | Acoustogram Printout (A) | 2-13, 2-14, 2-15 | This printout is the same as the CRT acoustogram display; that is, the data received is plotted against time into the frame and the frame number.  The hard-copy printout, however, may display one, three, or six receiver acoustograms from one selected array. |
| 4. | Digital Tape Data Dump Printout | 2-16 | The digital tape containing vortex location solutions can be printed out on the hard-copy printer for quick review.  Each file can be printed sequentially in either an automatic (continuous) or manual (page-by-page) mode. |

```
         P.A.V.S.S. PROCESSING PARAMETERS  -  RUN  6  -  WIND = -8.7,   -.0

A = MODE (R,P) - PLOT TIME (1,2,3 MIN)              R           2
B = AUTO START  -  AUTO STOP (E,D)                  E           E
C = ACTIVE ARRAYS                                   X           Y
D = L.O.S. DATA FREQUENCY T. C.                     12.0        12.0
E = L.O.S. TRACKER T. C.                            6.0         6.0
F = L.O.S. DATA FREQUENCY REQUIRED                  0.5         0.5
G = DELAY DATA FREQUENCY T. C.                      3.0         3.0
H = DELAY TRACKER T. C.                             1.5         1.5
I = DELAY DATA FREQUENCY REQUIRED                   0.4         0.4
J = FRAME DURATION (MSEC)                           950         950
K = STARTING FRAME NUMBER                           8           12
L = LOS GUARD BANDS -/+ (.25 MSEC)                  25          35          ─ Page 1
M = STARTING ALTITUDE                               80.0        80.0
N = MET. ELEMENT SELECTION (E,F,L,R)                R           L
O = LOCK OUT ELEMENT SELECTION (L,R,S,C)            S           S
P = WIND SWITCH POINT (+ & -)                       5.0         5.0
Q = L.O.S. DETERMINATION METHOD (M,T)               T           T
R = PULSE LENGTH (MSEC)                             3           3

S = FREQUENCY (WITH - AGAINST) WIND (HZ)            2000        2000

T = MET. DATA - WIND (FT/SEC) - REL. HUM. (%)       0.0         50.0
U = TEMPERATURE. PLAYBACK STARTUP                   32.0        32.67
V = DISPLAY MODE (GT-40) (VERS)                     AI-3        F1
W = CONSTANT PATH LENGTH - DATE                     5.0         001:08:42:33
X = AIRPORT CODE - TAPE NUMBER                      K           1


    X - ELEMENT POSITIONS. X ARRAY
    -480.0   -330.0   -180.0   -30.0    30.0     180.0    330.0    480.0

    Y - ELEMENT POSITIONS. Y ARRAY
    -460.0   -320.0   -180.0   -40.0    40.0     180.0    320.0    460.0

    Z - ELEMENT POSITIONS. Z ARRAY
    -460.0   -320.0   -180.0   -40.0    40.0     180.0    320.0    460.0

    MASK POSITIONS - ARRAY 1
    500   940   0                400   940   0
    300   940   0                300   940   0                          ─ Page 2
    400   940   0                500   940   0

    MASK POSITIONS - ARRAY 2
    500   940   0                400   940   0
    300   940   0                300   940   0
    400   940   0                500   940   0
```

FIGURE 2-10  Processing Parameters, Versatec Printout

P.A.V.S.S. - VORTEX POSITION VS. TIME (1 DIVISION = 20 SEC.) - ARRAY X - RUN 2 - B-727 - WIND = .0



PUN START TIME = 153:08:09:33

NOTE: Port (left) and starboard (right) are used to designate
      directions relative to the runway center-line as viewed
      by a pilot landing on the runway.  The following-listed
      symbols are used:
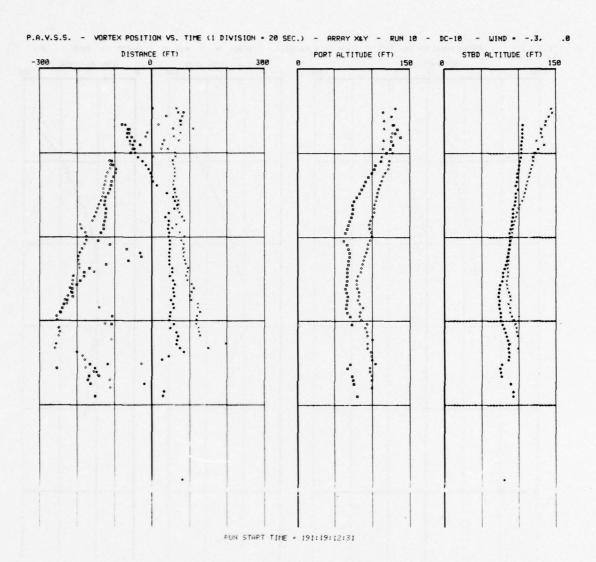
      o = Port
      x = Starboard
      - = Port
      + = Starboard

FIGURE 2-11   Plot (P), Versatec Printout

2-13

P.A.V.S.S. - VORTEX POSITION VS. TIME (1 DIVISION = 20 SEC.) - ARRAY X&Y - RUN 10 - DC-10 - WIND = -.3, .0



RUN START TIME = 191:19:12:31

NOTE: Port (left) and starboard (right) are used to designate
directions relative to the runway center-line as viewed
by a pilot landing on the runway. The following-listed
symbols are used:

o = Port
□ = Port
x = Starboard
● = Starboard
- = Port
+ = Starboard

FIGURE 2-12   Plot (P) for Both Active Arrays, Versatec Printout

2-14

P.A.V.S.S. - RETURN DELAY VS. TIME (1 DIVISION = 20 FRAMES) - ARRAY Y - RUN 15 - B-727 - WIND = 17.6

ELEMENT 6
DELAY (MSEC)

200    400    600    800    1000

RUN START TIME = 001:23:38:10

FIGURE 2-13   Single Acoustogram (A), Versatec Printout

P.A.V.S.S. - RETURN DELAY VS. TIME (1 DIVISION = 20 FRAMES ) - ARRAY Y - RUN 15 - B-727 - WIND = 17.6

ELEMENTS 2,4,5
DELAY (MSEC)

RUN START TIME = 001:23:38:10

FIGURE 2-14   Three Acoustograms (A), Versatec Printout

P.A.V.S.S. - RETURN DELAY VS. TIME (1 DIVISION = 20 FRAMES) - ARRAY X - RUN 6 - B-747 - WIND = -1.6

ELEMENTS 1,2,3,4,5,6
DELAY (MSEC)

RUN START TIME = 153:03:41:23

FIGURE 2-15   Six Acoustograms (A), Versatec Printout

FILE    2      ERROR? N

HEADER

RUN    17                    TAPE    1

AIRPORT K                    AIRCRAFT B-747

Milliseconds — FRAME LENGTH    950         950

Hertz — FREQUENCY    2000         2000

ARRAY CONFIGURATION 00001101

Feet — TIME    10:56:44

ARRAY 1 SENSRS   -400.0 -330.0 -100.0  100.0  330.0  400.0
ARRAY 2 SENSRS   -400.0  320.0 -100.0  100.0  320.0  400.0

Feet Per Second — ARRAY 1 SOUND SPEEDS  1122.5 1136.9
ARRAY 2 SOUND SPEEDS  1125.0 1135.4

Degrees, F. — TEMPERATURE   70.00

| | | FILE 2 | | ARRAY 1 | | |
|---|---|---|---|---|---|---|
| PORT VORTEX | | STBD VORTEX | | INDICATOR | FRAME | ERROR? |
| DIST | HT | DIST | HT | WORDS | NO. | |
| .0 | .0 | .0 | .0 | 000 000 | 1 | N |
| .0 | .0 | .0 | .0 | 000 000 | 2 | N |
| .0 | .0 | .0 | .0 | 000 000 | 3 | N |
| .0 | .0 | .0 | .0 | 000 000 | 4 | N |
| .0 | .0 | .0 | .0 | 000 000 | 5 | N |
| .0 | .0 | .0 | .0 | 000 000 | 6 | N |
| .0 | .0 | .0 | .0 | 000 000 | 7 | N |
| .0 | .0 | .0 | .0 | 000 000 | 8 | N |
| .0 | .0 | .0 | .0 | 000 000 | 9 | N |
| .0 | .0 | .0 | .0 | 000 004 | 10 | N |
| .0 | .0 | .0 | .0 | 000 008 | 11 | N |
| .0 | .0 | .0 | .0 | 000 007 | 12 | N |
| .0 | .0 | .0 | .0 | 100 060 | 13 | N |
| .0 | .0 | .0 | .0 | 000 042 | 14 | N |
| .0 | .0 | .0 | .0 | 000 051 | 15 | N |
| 12.1 | 174.1 | .0 | .0 | 000 046 | 16 | N |
| 11.0 | 156.1 | .0 | .0 | 100 065 | 17 | N |
| 15.9 | 152.1 | .0 | .0 | 100 074 | 18 | N |
| 28.5 | 142.0 | .0 | .0 | 100 042 | 19 | N |
| 96.0 | 129.1 | .0 | .0 | 100 066 | 20 | N |
| 113.7 | 127.9 | .0 | .0 | 000 076 | 21 | N |
| 40.0 | 125.9 | .0 | .0 | 000 065 | 22 | N |
| .0 | 100.6 | .0 | .0 | 100 077 | 23 | N |
| 34.3 | 113.8 | .0 | .0 | 000 067 | 24 | N |
| 42.5 | 103.5 | .0 | .0 | 100 076 | 25 | N |
| 0.4 | 106.4 | .0 | .0 | 000 077 | 26 | N |

| | | FILE 2 | | ARRAY 1 | | |
|---|---|---|---|---|---|---|
| PORT VORTEX | | STBD VORTEX | | INDICATOR | FRAME | ERROR? |
| DIST | HT | DIST | HT | WORDS | NO. | |
| 57.5 | 97.5 | .0 | .0 | 100 077 | 27 | N |
| 61.2 | 90.8 | .0 | .0 | 100 077 | 28 | N |
| 100.4 | 89.2 | .0 | .0 | 100 077 | 29 | N |
| 100.1 | 95.0 | .0 | .0 | 100 077 | 30 | N |
| 111.1 | 82.1 | .0 | .0 | 100 077 | 31 | N |
| 115.2 | 79.0 | .0 | .0 | 100 077 | 32 | N |
| 115.4 | 78.0 | .0 | .0 | 100 077 | 33 | N |
| 120.5 | 76.1 | .0 | .0 | 100 077 | 34 | N |
| 147.9 | 73.0 | .0 | .0 | 100 077 | 35 | N |
| 141.1 | 70.4 | .0 | .0 | 100 077 | 36 | N |
| 143.0 | 66.1 | .0 | .0 | 100 077 | 37 | N |
| 160.0 | 67.2 | .0 | .0 | 100 073 | 38 | N |
| 145.1 | 66.2 | .0 | .0 | 100 073 | 39 | N |
| 148.1 | 64.5 | .0 | .0 | 100 071 | 40 | N |
| 150.1 | 62.0 | .0 | .0 | 000 070 | 41 | N |
| 202.1 | 56.0 | .0 | .0 | 000 070 | 42 | N |
| 209.0 | 55.4 | .0 | .0 | 000 070 | 43 | N |
| 190.2 | 53.6 | .0 | .0 | 000 070 | 44 | N |
| 193.2 | 53.5 | .0 | .0 | 000 070 | 45 | N |
| 198.6 | 45.3 | .0 | .0 | 000 070 | 46 | N |
| 250.9 | 41.9 | .0 | .0 | 000 070 | 47 | N |
| 271.9 | 36.5 | .0 | .0 | 000 070 | 48 | N |
| 301.9 | 36.5 | .0 | .0 | 000 070 | 49 | N |
| 310.0 | 55.4 | .0 | .0 | 000 070 | 50 | N |
| 235.7 | 44.9 | .0 | .0 | 000 070 | 51 | N |
| 247.1 | 43.7 | .0 | .0 | 000 070 | 52 | N |

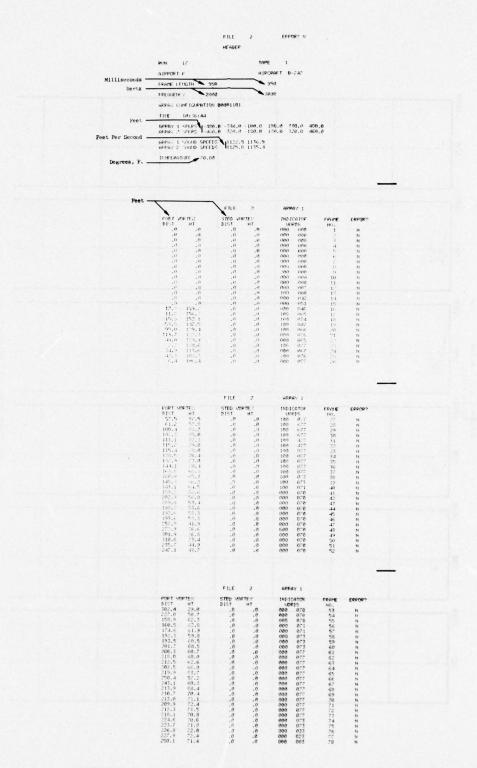| | | FILE 2 | | ARRAY 1 | | |
|---|---|---|---|---|---|---|
| PORT VORTEX | | STBD VORTEX | | INDICATOR | FRAME | ERROR? |
| DIST | HT | DIST | HT | WORDS | NO. | |
| 302.4 | 24.0 | .0 | .0 | 000 070 | 53 | N |
| 227.0 | 50.7 | .0 | .0 | 000 070 | 54 | N |
| 158.9 | 62.1 | .0 | .0 | 000 070 | 55 | N |
| 160.5 | 62.6 | .0 | .0 | 000 071 | 56 | N |
| 174.6 | 61.9 | .0 | .0 | 000 071 | 57 | N |
| 192.3 | 59.8 | .0 | .0 | 000 073 | 58 | N |
| 193.5 | 60.5 | .0 | .0 | 000 073 | 59 | N |
| 201.7 | 60.5 | .0 | .0 | 000 073 | 60 | N |
| 208.3 | 60.7 | .0 | .0 | 000 077 | 61 | N |
| 218.0 | 60.0 | .0 | .0 | 000 077 | 62 | N |
| 212.5 | 62.6 | .0 | .0 | 000 077 | 63 | N |
| 202.5 | 66.0 | .0 | .0 | 000 077 | 64 | N |
| 219.3 | 63.7 | .0 | .0 | 000 077 | 65 | N |
| 250.4 | 57.2 | .0 | .0 | 000 077 | 66 | N |
| 343.1 | 60.3 | .0 | .0 | 000 077 | 67 | N |
| 213.9 | 68.4 | .0 | .0 | 000 077 | 68 | N |
| 210.7 | 70.4 | .0 | .0 | 000 077 | 69 | N |
| 213.0 | 71.1 | .0 | .0 | 000 077 | 70 | N |
| 209.9 | 72.4 | .0 | .0 | 000 077 | 71 | N |
| 212.3 | 71.5 | .0 | .0 | 000 077 | 72 | N |
| 218.1 | 70.8 | .0 | .0 | 000 077 | 73 | N |
| 224.6 | 70.6 | .0 | .0 | 000 073 | 74 | N |
| 223.7 | 71.9 | .0 | .0 | 000 073 | 75 | N |
| 226.8 | 72.8 | .0 | .0 | 000 033 | 76 | N |
| 227.9 | 72.4 | .0 | .0 | 000 023 | 77 | N |
| 250.1 | 71.4 | .0 | .0 | 000 003 | 78 | N |

FIGURE 2-16   Digital Data Dump, Versatec Printout

2-18

respectively) describe in a step-by-step manner the parameter limits and sequence of operations required for proper operation of the PAVSS.

NOTE

For continuity and for simplicity of reference, the steps described below have been numbered sequentially from 1. through 65. without regard to the particular paragraph under which they are presented.
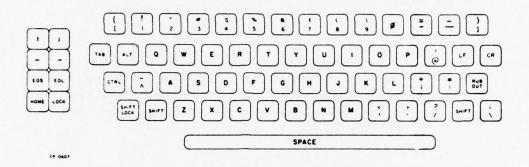
2.2.1  Program Loading

The PAVSS operating program is loaded from magnetic tape via the digital magnetic tape recorder (7-track). This is done as follows:

1.  Turn on the PAVSS by rotating the key-operated Power switch on the GT-40 (shown in Figure 2-17) clockwise (CW) to the POWER position. This applies power to the GT-40 processor, the CRT display, both of the magnetic tape units, and the hard-copy printer/plotter (Versatec).

NOTE

After start-up, the key-operated power switch on the GT-40 can be set at the PANEL LOCK position and the key removed, if desired, to prevent inadvertent or unauthorized operation of the GT-40 switches.

2.  Make sure that controls on the digital magnetic tape unit (TU-10), shown in Figure 2-18, are set as follows:

a.  The PWR ON/PWR OFF (Power On/Power Off) switch is set at the PWR ON position.

ADDRESS/DATA SWITCHES
CONSOLE SWITCHES
POWER SWITCH
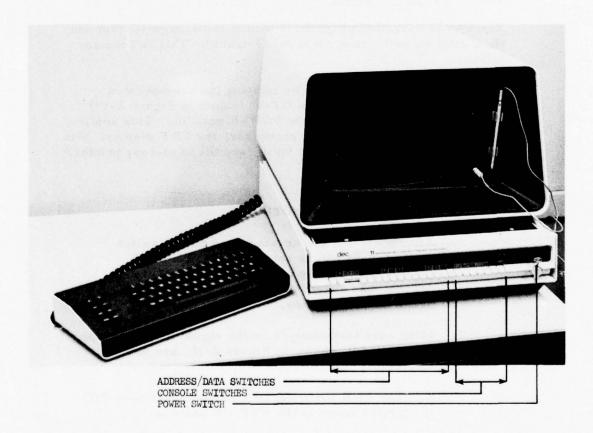
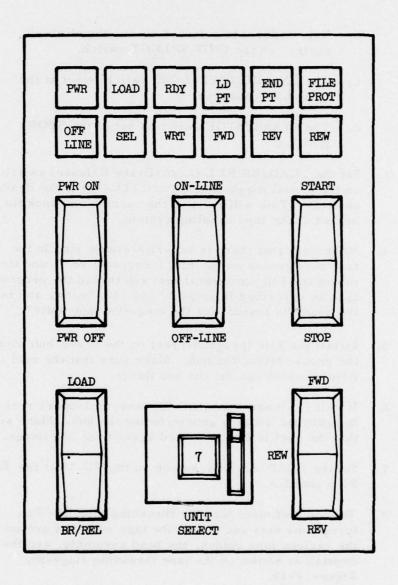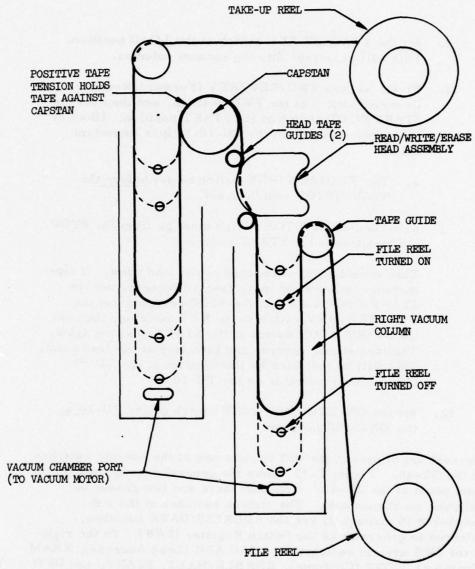FIGURE 2-17   GT-40 CRT Terminal and Keyboard Unit

2-20

FIGURE 2-18   Digital Tape Recorder (TU-10) Control Panel Layout

b.    Unit 0 (Zero) is selected via the thumbwheel
control on the UNIT SELECT switch.

c.    The ON-LINE/OFF-LINE switch is set at the
OFF-LINE position.

d.    The START/STOP switch is set at the STOP
position.

3.    Set the LOAD/BR REL (Load/Brake Release) switch
on the digital magnetic tape unit (TU-10) at the Brake*
position.  This will release the vacuum and lock the
brakes in the tape handling system.

4.    Make sure that there is no write-enable ring in the
tape reel groove on the File (program) reel, and then
mount the File (program) reel and thread the program
tape as described in steps 5. and 11., below, and in
the vendor's manual for the magnetic tape unit**.

5.    Install the File (program) reel on the lower hub with
the groove facing the hub.  Make sure that the reel is
firmly seated against the hub flange.

6.    Install (or make sure that) the take-up (upper) reel is
in position, with the groove facing the hub.  Make sure
that the reel is firmly seated against the hub flange.

7.    Set the LOAD/BR REL switch on the TU-10 at the BR/
REL position.

8.    Unwind sufficient tape for threading from the File
(program) reel and thread the tape over and around
the various tape guides, the head assembly, and the
capstan as shown on the tape threading diagram,
Figure 2-19.

9.    Wind about five turns of tape onto the take-up reel.

---

*This is the unmarked center position.
**TM-11 DEC Magtape System, DEC-11-HTMAA-C-D, Section 3.3.

TAKE-UP REEL

POSITIVE TAPE
TENSION HOLDS
TAPE AGAINST
CAPSTAN

CAPSTAN

HEAD TAPE
GUIDES (2)

READ/WRITE/ERASE
HEAD ASSEMBLY

TAPE GUIDE

FILE REEL
TURNED ON

RIGHT VACUUM
COLUMN

FILE REEL
TURNED OFF

VACUUM CHAMBER PORT
(TO VACUUM MOTOR)

FILE REEL

NOTE: Tape is automatically drawn into vacuum
columns when LOAD/BR REL switch is set
to LOAD position.

FIGURE 2-19   Digital Tape Recorder (TU-10) Tape Threading Diagram

10. Set the LOAD/BR REL switch at the LOAD position. This will draw tape into the vacuum columns.

11. First, set the FWD/REW/REV (Forward/Rewind/ Reverse) switch at the FWD position, and then set the START/STOP switch at the START position. (Both of these switches are on the TU-10.) It is important that:

   a. The FWD/REW/REV switch be set before the START/STOP switch is set.

   b. The START/STOP switch must go from the STOP position to the START position.

   This should advance the tape to the load point. If tape motion continues for more than 10 seconds, set the START/STOP switch at the STOP position, set the FWD/REW/REV switch to the REV position, then set the START/STOP switch at the START position again. The tape should reverse and then stop at the load point. This will be indicated by illumination of the LD PT (Load Point) indicator on the TU-10.

12. Set the ON-LINE/OFF-LINE switch on the TU-10 at the ON-LINE position.

The next set of operations will require use of the console switches on the GT-40. Figure 2-17 shows the general arrangement of the front panel of the GT-40. Note that there are two groups of switches on the console. The sixteen switches at the left (numbered 15 through 0) are the ADDRESS/DATA switches, referred to generally as the Switch Register (SWR). To the right of the SWR are six switches -- LOAD ADR (Load Address), EXAM (Examine), CONT (Continue), ENABLE/HALT, START, and DEP (Deposit) -- used to control operation of the computer. Their use is explained later. The SWR permits entry of a 16-bit binary word used to represent the octal data or address being loaded into the computer. An indicator light above each switch in the SWR permits ready verification or readout of the address or data entered on the switches. When these tab-type switches are in

the Normal (horizontal) position, a ZERO is entered. When they are in the Up position, a ONE is entered. (It is not essential that the operator understand the detailed workings of the SWR since only two settings, both clearly described below, are used during normal operation of the PAVSS.)

13. Set the ENABLE/HALT switch on the GT-40 at the HALT (Normal) position.

14. Set the SWR to $173136_8$ ($1\ 111\ 011\ 001\ 011\ 110_2$). This is done by setting switches 15, 14, 13, 12, 10, 9, 6, 4, 3, 2, 1 at the ONE (Up) position. The remaining SWR switches are set at the ZERO (Normal) position.

15. Momentarily depress the LOAD ADR (Load Address) switch (on the GT-40). Verify that the indicator lights on the SWR are lighted above each switch set at the ONE (Up) position. If they are not, depress the START switch and then again momentarily depress the LOAD ADR switch.

16. Set the ENABLE/HALT switch at the ENABLE (Up) position.

17. Momentarily depress the START switch. This should cause:

    a. The digital magnetic tape unit (TU-10) to advance the tape slightly.

    b. A prompt to appear on the GT-40 CRT screen. Make sure that the BRIGHTNESS control on the CRT (to the right of the screen) is set to make the message visible. (Clockwise rotation of this switch increases the brightness of the display.)

18. Clear the SWR by setting each of the switches at the ZERO (Normal) position.

19. Set switch 15 on the SWR at the ONE (Up) position. At this point:

a. The program should load into the machine auto-
   matically.

b. The tape should rewind automatically upon com-
   pletion of the program loading.

c. A new prompt should appear on the CRT screen.

20. Set switch 15 on the SWR at the ZERO (Normal) position.
    This will cause Page 1 of the PAVSS processing para-
    meters to be displayed on the CRT.

Figure 2-20 shows a display of both pages of the processing para-
meters. The next steps (Steps 21. through 26.) are used to alter
the data on the right-hand portion of both pages should that be
desired. Figure 2-20, it should be noted, shows only the pre-
viously established data. The person responsible for conducting
the test (test conductor) must instruct the operator if different
data is to be entered. A very specific sequence must be followed
to enter data correctly. The change is made by using the key-
board unit.

NOTE

All letters are capital (upper case). Therefore,
whenever a letter is entered, the SHIFT key must
be held down while the letter key is depressed (or
the SHIFT LOCK key depressed and left in that
position if several letters are to be entered
sequentially). Numbers (except for number 1)
must not be entered with the SHIFT key
depressed.

If at any time it is desired to return to the processing parameter
display, the following operating sequence is used:

a. Momentarily depress the ↓ (Down arrow) key
   on the keyboard unit. (This serves as a Stop key.)
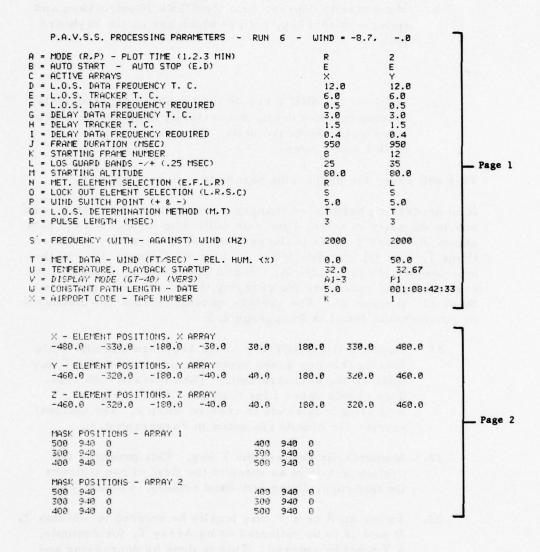
and then either:

```
        P.A.V.S.S. PROCESSING PARAMETERS  -  RUN  6  -  WIND = -8.7,  -.0

A = MODE (R,P) - PLOT TIME (1,2,3 MIN)              R          2
B = AUTO START  -  AUTO STOP (E,D)                  E          E
C = ACTIVE ARRAYS                                   X          Y
D = L.O.S. DATA FREQUENCY T. C.                     12.0       12.0
E = L.O.S. TRACKER T. C.                            6.0        6.0
F = L.O.S. DATA FREQUENCY REQUIRED                  0.5        0.5
G = DELAY DATA FREQUENCY T. C.                      3.0        3.0
H = DELAY TRACKER T. C.                             1.5        1.5
I = DELAY DATA FREQUENCY REQUIRED                   0.4        0.4
J = FRAME DURATION (MSEC)                           950        950
K = STARTING FRAME NUMBER                           8          12
L = LOS GUARD BANDS -/+ (.25 MSEC)                  25         35
M = STARTING ALTITUDE                               80.0       80.0
N = MET. ELEMENT SELECTION (E,F,L,R)                R          L
O = LOCK OUT ELEMENT SELECTION (L,R,S,C)            S          S
P = WIND SWITCH POINT (+ & -)                       5.0        5.0
Q = L.O.S. DETERMINATION METHOD (M,T)               T          T
R = PULSE LENGTH (MSEC)                             3          3

S = FREQUENCY (WITH - AGAINST) WIND (HZ)           2000       2000

T = MET. DATA - WIND (FT/SEC) - REL. HUM. (%)      0.0        50.0
U = TEMPERATURE, PLAYBACK STARTUP                  32.0        32.67
V = DISPLAY MODE (GT-40) (VERS)                    A1-3       P1
W = CONSTANT PATH LENGTH - DATE                    5.0        001:08:42:33
X = AIRPORT CODE - TAPE NUMBER                      K          1
```

← Page 1

```
X - ELEMENT POSITIONS, X ARRAY
-480.0   -330.0   -180.0   -30.0    30.0    180.0    330.0    480.0

Y - ELEMENT POSITIONS, Y ARRAY
-460.0   -320.0   -180.0   -40.0    40.0    180.0    320.0    460.0

Z - ELEMENT POSITIONS, Z ARRAY
-460.0   -320.0   -180.0   -40.0    40.0    180.0    320.0    460.0

MASK POSITIONS - ARRAY 1
500   940   0               400   940   0
300   940   0               300   940   0
400   940   0               500   940   0

MASK POSITIONS - ARRAY 2
500   940   0               400   940   0
300   940   0               300   940   0
400   940   0               500   940   0
```

← Page 2

**FIGURE 2-20   PAVSS Processing Parameter Display**

b.  Momentarily depress first the CTRL (Control) key and then the @ (At) key, both of which are on the keyboard unit,

or

c.  Depress the SHIFT key on the keyboard unit and while holding this key down, momentarily depress the 1 key (also on the keyboard unit). Then release both the SHIFT and 1 keys.

This will cause the processing parameters to be displayed.

If no processing parameter changes are required, the system can now be operated in a real-time data collecting mode. All the data shown in Figure 2-20 is in the system. Only the array selection (Page 1, Line C), the date (Page 1, Line W, Column 2), and the tape number (Page 1, Line X, Column 2) need to be changed. An example of the procedure for changing these entries is given in Steps 21. through 26. The various optional entries are discussed in considerable detail in Paragraph 2.3.

21.  Depress the SHIFT key on the keyboard unit and while holding this key down, momentarily depress the C key (also on the keyboard unit). Then release both keys. This should cause Line C on the CRT to brighten, indicating it is ready to receive entries. The optional entries for Line C are noted in Paragraph 2.3.

22.  Momentarily depress the 1 key. This prepares the system to accept an entry in the first of two columns (in this case, in the left-hand column, Column 1).

23.  Either an X or a Y may legally be entered in Column 1. If data is to be collected using Array Y, for example, a Y must be entered. This is done by depressing and holding down the SHIFT key and then depressing the Y key. Both keys are then released. This should enter Y in Column 1 (left-hand column) of Line C.

24. Momentarily depress the TAB key. This completes the left-hand column entry and prepares the system for an entry in the right-hand column.

25. Either Y or Z may be entered in the right-hand column of Line C. In this case, since a Y has already been entered in Column 1 on that line, a Z must be entered in Column 2. This is done by depressing and holding down the SHIFT key and then depressing the Z key. Both keys are then released.

26. Momentarily depress the CR (Carriage Return) key. This completes the right-hand column entry and causes Line C to be entered in the computer. This will be indicated by the display for Line C returning to its normal brightness.

This cycle of steps (Steps 21. through 26.) must be repeated for each line on Page 1 on which a change is to be made.

Some mistakes in parameter entry will cause the keyboard bell to ring and the CRT to display the message INPUT ERROR! When this occurs, go back and repeat the entry of correct data on the line on which the change was being made at the time the bell rang and the message was displayed. This should eliminate the error indication.

When operations to change Page 1 have been completed, Page 2 can be displayed and any desired changes made.

27. To display Page 2, perform the following keyboard functions on the keyboard unit.

    a. Depress and hold down the SHIFT key.

    b. Depress the Y key.

    c. Release both the SHIFT and the Y keys.

    d. Momentarily depress the 1 key.

This will cause Page 2 of the processing parameters
for the PAVSS to be displayed on the CRT.

28. To change the array element positions:

    a.   Depress and hold down the SHIFT key.

    b.   Depress the appropriate key (X, Y, or Z) for the
         array whose parameters are to be changed.

    c.   Release both the SHIFT key and the X, Y, or Z key.

This will cause all of the element position numbers of
the selected array to be removed from the display.
Next (assuming a change is to be made in the X array):

    a.   Enter the new number for the first X array element
         position in the X array (for example, -480.0).

    b.   Momentarily depress the TAB key.

    c.   Enter the number of the second element position
         in the X array.

    d.   Momentarily depress the TAB key.

    e.   Continue in this manner until the last number has
         been entered.

    f.   Momentarily depress the TAB key.  This returns
         the display to Page 1.

Steps 27. and 28. may be repeated (using the appropriate keys)
as required to change other aspects of the array geometry.

29. The mask regions on Page 2 can be changed as follows.

    a.   Depress and hold down the SHIFT key.

    b.   Depress the Z key.

    c.   Release both the SHIFT key and the Z key.

d.  Depress and release the 1 key.  This will display Page 2.

e.  Depress and release the 1 key.  This will erase MASK POSITIONS-ARRAY 1 for receiver 1. Figure 2-21 indicates the arrangement used to display the mask data.   Operation of the 2 key would have erased the MASK POSITION-ARRAY 1 for receiver 2, etc.   The Mask regions are established as follows:

(1)  The first number represents the time (in milliseconds) of the end of the first period that data is masked out (prevented from entering the system).  (Note that the system starts up with data masked out -- prevented from entering the system. )

(2)  The second number represents  (in milliseconds) the end of the time during which the first data gate is open to allow data to enter the system.

(3)  The third number represents the time (in milliseconds) at which the second masked out region ends (which began at the time established by the second number).

(4)  The process is repeated until all of the mask positions have been established.

The next to the last number should be about 10 milliseconds less than the duration of the frame for that array (as entered on Page 1, Line J).  The last number should be a ZERO.  Up to seven numbers can be entered.  There should be an odd number of entries on each line.

The following steps (Steps 30. through 47. ) cover the procedure used to load tape reels onto both the analog and digital tape recorders for data collection or data playback. Further details regarding operation of the analog recorder are given in the vendor's manual*.

---

*CPR 4010 Magnetic Tape Recorder/Reproducer, Operation and Maintenance (992630-0004).

MASK POSITIONS - ARRAY n

| OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | 0 |
|---|---|---|---|---|---|---|

RECEIVER 1

| OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | 0 |

RECEIVER 3

| OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | 0 |

RECEIVER 5

| OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | 0 |

RECEIVER 2

| OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | 0 |

RECEIVER 4

| OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | OPEN GATE | CLOSE GATE | 0 |

RECEIVER 6

NOTE:

1. Open and Close Gate times are in milliseconds.

2. System starts with data masked out--prevented from entering the system.

FIGURE 2-21  Mask Arrangements

30. Make sure that the analog magnetic tape recorder (CPR 4010) is turned on. It is turned on by setting the Power On/Off switch (shown on Figure 2-22) at the ON position.

31. Install an empty 10-1/2-inch reel (take-up reel) for 1-inch tape on the lower tape mounting hub.

32. Install a full reel (supply) of new (or completely de-gaussed) magnetic tape on the upper tape mounting hub. Make sure that the tape is coming down off the reel on the left-hand side facing the tape transport, as shown on Figure 2-23.

33. Pull approximately four feet of tape off the supply (upper) reel.

34. Thread the tape around the various rollers, guides, heads, and capstans along the path indicated on Figure 2-23.

35. Wrap the free end of the tape around the take-up (lower) reel in a counter-clockwise (CCW) direction and pull any extra tape back up onto the supply (upper) reel to remove all slack.

36. While holding the free end of the tape against the hub of the take-up reel, rotate the take-up reel clockwise several turns until the tape binds itself onto the reel. Make sure that there is no 'bump' on the take-up (lower) reel where the tape overlaps.

37. After the tape has been threaded as shown in Figure 2-23 and described in steps 30. through 36., above, rotate the take-up reel manually until the READY indicator light on the CPR 4010 goes ON. If this light *fails to go on*, make sure that the supply and tension rollers are correctly positioned (as indicated in Figure 2-23).

The analog magnetic tape recorder is now ready for use in data collection. A similar procedure is used in preparing for playing back data.

HANDLE

REPRODUCE
ELECTRONICS

RECORD
ELECTRONICS

VOICE LOGGING
UNIT (OPTIONAL)

TAPE SERVO
(OPTIONAL)

MONITOR METER
(OPTIONAL)

TAPE SPEED
CONTROL

CONTROL PANEL

POWER ON/OFF
SWITCH
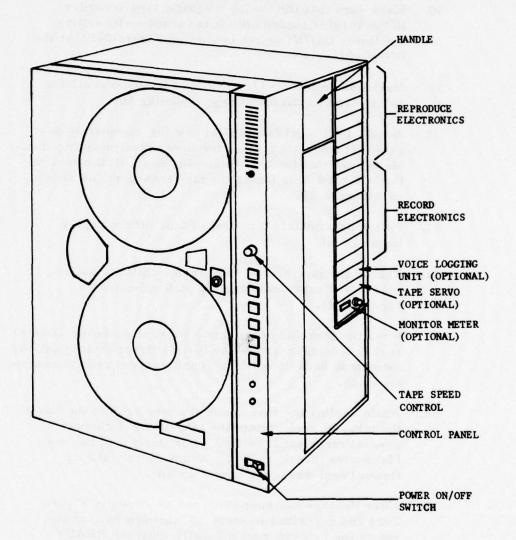
FIGURE 2-22   Analog Tape Recorder (CPR-4010 System)

2-34

ADJUSTABLE TAPE GUIDE

SUPPLY REEL

SUPPLY TENSION SENSOR ROLLERS

CAPSTAN

HEAD ASSY

GUIDE ROLLER

DAMPING ROLLER

GUIDE ROLLER

CAPSTAN

TAPE GUIDE

TAKEUP TENSION SENSOR ROLLERS

ADJUSTABLE TAPE GUIDE

TAKEUP REEL

TAPE SPEED CONTROL

datatape
CPR 4010
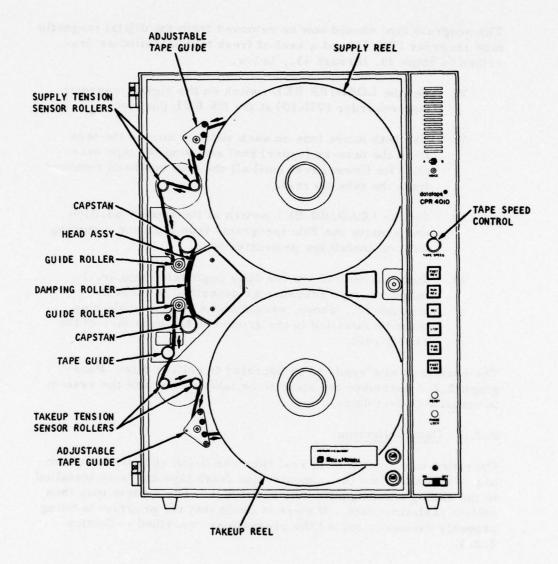
FIGURE 2-23   Analog Tape Recorder (CPR-4010) Tape Threading Diagram

The program tape should now be removed from the digital magnetic tape recorder (TU-10) and a reel of fresh tape installed as described in Steps 38. through 41., below.

38. Set the LOAD/BR REL switch on the digital magnetic tape recorder (TU-10) at the BR REL position.

39. Use both hands (one on each reel) to unwind the tape from the take-up (upper) reel and wind the tape onto the File (lower) reel until all the tape has been removed from the take-up reel.

40. Set the LOAD/BR REL switch at the Brake* position and remove the File (program) tape from the mounting hub and install the protective band.

41. Install a reel of new (or fully degaussed) tape on the magnetic tape recorder as described in Steps 2. through 12., above, except that a write-enable ring must be installed in the groove on the back face of the supply reel.

The system is now ready to be operated to collect data. Paragraph 2.2.2 describes the steps to be taken to operate the system to actually collect data.

## 2.2.2   Data Collection

Operation to collect data in real time can begin after the program has been loaded into the computer and fresh tape has been installed in the analog and magnetic tape recorders. The system may then collect real-time data. If there is doubt that the program is being properly executed, reload the program as described in Section 2.2.1.

42. Enter the best estimates of wind and relative humidity on Line T of Page 1 of the processing parameters.

_____

*This is the unmarked center position.

43. Enter the correct date on Page 1, Line W, Column 2.

44. Enter the correct airport code and tape number on Page 1, Line X, Columns 1 and 2, respectively.

45. Enter the two arrays to be operated on Page 1, Line C, Columns 1 and 2.

46. Disable automatic control by placing a D in Columns 1 and 2, Page 1, Line B.

47. Turn off power to the analog recorder and place the digital recorder off line.

48. Start the transmitters by momentarily depressing the EOS and LOCK keys on the keyboard unit simultaneously.

49. Start the LOS trackers by depressing the ◄── (Left arrow) key on the keyboard unit. The system should now begin to fill the trackers, and to update the LOS guard band locations and word values (at 15-second intervals).

50. If after about two minutes the wind values look reasonably close to the estimated values, momentarily depress the HOME (ready to run) key on the keyboard unit, wait three or more seconds, and then momentarily depress the ↑ (Up arrow) key to start the run. Wait until a time at least as long as the product of the values on Page 1, Lines K and J has elapsed. Watch to see if the LOS trackers are illuminated while the delay trackers are not (as indicated on the dot display in the lower right corner of the CRT - see Table 2-1 and Figure 2-8). Adjust the gain potentiometers for the lowest value that: (a) fills the LOS trackers, and (b) does not produce delay tracker indications (during a non-vortex period). The 12 gain potentiometer controls are panel-mounted below the 28 recorder channel gain controls on the analog tape recorder rack. If the delay trackers illuminate, it means that the guard bands are incorrectly located. When this happens, set all of the gain

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potentiometer controls to the 3 o'clock position and
stop the run by pressing the ↓ (Down arrow) key
on the keyboard unit. Go to the processing parameters
(via appropriate action of the CNTL and @, or SHIFT 1
keys on the keyboard unit) and alter Page 1, Line L
to read 150 and 150. Allow the system to continue
operating for at least one minute, then change Line L
to 100 and 100. Allow the system to continue opera-
ting for at least one minute, then change Line L to
50 and 50. Wait again, then set Line L to 35 and 35.
This should capture the LOS signals and enter the guard
bands settings. When the gain has been set correctly
insure that Page 1, Line V contains the desired dis-
play and printout information. Place the digital tape
recorder on line, and turn on the analog tape recorder,
whose tape speed control should be set to R (Remote),
making sure that the STOP switch has been set (as
indicated by being illuminated) and the READY light
is ON.

51. Momentarily depress the HOME (ready to run) key on
the keyboard unit. This should start the analog tape
recorder; cause the CRT display to shift to the display
corresponding to the entry on Page 1, Line V, Column 1;
and cause the Versatec to write the appropriate header
(not visible at this time).

52. The start of run (SOR) can be entered only after either:
(a) the paper in the hard-copy printer/plotter has stopped
moving following completion of Step 51., above, or, if
the hard-copy printer/plotter is not used, 1-1/2 seconds
have elapsed following completion of Step 51., above.
The start of run is initiated by momentarily depressing
the ↑ (Up arrow) on the keyboard unit. When this
is done, the SOR time will be entered automatically and
the run will start.

53. When the run is to be terminated, momentarily depress
the ↓ (Down arrow) on the keyboard unit. This stops
the run and enters the SOR time at the end of the hard
copy.

54. The next run is started by entering the new aircraft identification (ID) and repeating Steps 42., 43., and 44. The run number will be incremented automatically.

The system is shut down by carrying out the following steps (Steps 55. through 57.).

55. End the current run (if it is in progress) by momentarily depressing the ↓ (Down arrow) on the keyboard unit.

56. Set the ENABLE/HALT switch on the GT-40 at the HALT position.

57. Rotate the key-operated Power switch on the GT-40 counterclockwise to the OFF position.

The system is re-started by carrying out the following-listed steps (Steps 58. through 65.).

58. Rotate the key-operated Power switch on the GT-40 clockwise to the POWER position.

59. Set the ENABLE/HALT switch on the GT-40 at the ENABLE (Up) position.

60. Momentarily depress the CONT (Continue) switch on the GT-40.

Once power for the digital magnetic tape unit (TU-10) has been turned off, it loses its tape position and a new reel of digital tape must be installed.

61. Manually take out any slack in the tape by winding it manually onto either the file (lower) reel or the tape-up (upper) reel. The LOAD/BR REL switch on the TU-10 should be set at the BR REL position when doing this.

62. Set the ON-LINE/OFF-LINE switch on the TU-10 at the OFF-LINE position.

63. Set the FWD/REW/REV switch on the TU-10 at the REW (Center) position.

64. Set the LOAD/BR REL switch at the LOAD position.

65. Set the START/STOP switch first at the STOP position and then at the START position. When this is done the tape should rewind and then stop automatically at the load point.

Remove the tape and install a new tape in accordance with the procedures described in Steps 2. through 12., above.

Make sure that the write-enable ring is in place on the new tape reel. The system can then be operated as described above.

If there is any question about whether the operating program is functioning properly, repeat Steps 1. through 41.

Section 2.3 describes not only how various plots are called up, but also the various display options.

## 2.3 SYSTEM OPERATING MODES

The preceding section presented the steps that are taken to operate the system in real time. This section covers the entry definitions, means of obtaining diagnostic and parameter printouts, operation in the playback mode, and the method of changing the contents of the system run counter. (Paragraphs 2.3.1, 2.3.2, 2.3.3, and 2.3.4, respectively). Paragraph 2.3.5 summarizes system operation.

The parameter limitations are noted in Figure 2-24. This figure shows a typical processing parameter printout. Two columns have been added to the right of the actual printout. These indicate the allowable entries normally used in the two parameter entry columns that appear immediately to the right of the parameter description entry. Note that on Page 1 each column represents a different function when the parameter description includes two items -- such as Line A (which contains MODE, and PLOT TIME). In those cases where the parameter description has only one item,

FIGURE 2-24  Typical Processing Parameter Printout with Operator Options Indicated

BEST AVAILABLE COPY

such as Line D (L.O.S. DATA FREQUENCY T.C.), Column 1
refers to the array entered on Line C, Column 1, and Column 2
refers to the array entered on Line C, Column 2. Numerical
entries can be integers (whole numbers) or floating point (decimal)
numbers as indicated in the key provided on Figure 2-24 or in the
two right-hand columns added to the printout shown in that figure.
Integer entries must start with a sign, a digit, or a space. A
floating point entry must start with a sign, a digit, a space, or a
decimal point.

## 2.3.1   Entry Definitions

Several of the processing parameter entries require definition.
These are provided on Table 2-3. The range of values for each
entry is given on Figure 2-24.

## 2.3.2   Parameter Printouts

The operator can obtain hard-copy printouts of the processing
parameters. Printout of these parameters during non-run periods
can be obtained by first depressing the     ↓ (Down arrow) on the
keyboard unit to make sure that the run has stopped, and then
depressing and keeping the CTRL (Control) key depressed and
depressing the D key (lower case, that is, without using the
SHIFT key). Both keys are then released.

## 2.3.3   Playback

Previously recorded analog data can be played back for reproces-
sing. The data need not have been acquired on the PAVSS system,
as long as the recorder track assignments are the same as those
in the PAVSS system. To play back data acquired by the PAVSS,
the system is operated in the so-called P-playback mode. This
is done by entering a P on Page 1, Line A, Column 1 of the pro-
cessing parameters. The tape should be installed on the analog
recorder and positioned several runs ahead of the location of the
particular run or runs to be played back. The system is then
operated as if it were being used in real time. The system can
be operated manually by using the     ↑ (Up arrow) and ↓ (Down
arrow) keys on the keyboard unit to start and stop, respectively,
its operation. Alternatively, it can be operated automatically by

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# TABLE 2-3  Processing Parameter Entry Definitions

| Line Page | | Definition |
|---|---|---|
| A | MODE (R, P, Q) - PLOT TIME (1, 2, 3) | **Column 1** <br> R = Real Time <br> P = Playback of data acquired with this system <br> Q = Playback of data not acquired with this system <br> **Column 2** <br> 1, 2, 3 (Time, in minutes) |
| B | AUTO START - AUTO STOP (E, D) | E - Function is enabled <br> D - Function is disabled |
| C | ACTIVE ARRAYS | There are three active arrays. As initially installed, X is the array farthest from the runway touchdown point, Z is the array closest to the runway touchdown point. The legal entries in Column 1 are X or Y; thus, for Column 2 are Y or Z. If Y is entered in Column 1, Z must be entered in Column 2. |
| D | L.O.S. DATA FREQUENCY T.C. | This number, the LOS data frequency time constant, sets the number of frames used by the system in determining the line-of-sight (LOS) data rate. The weighting is exponential, with recent data more heavily weighted than older data. |
| E | L.O.S. TRACKER T.C. | This number, the LOS tracker time constant, establishes the maximum time constant for the LOS tracker in terms of number of frames. The actual time constant depends on the data rate. |
| F | L.O.S. DATA FREQUENCY REQUIRED | This number is the required ratio of actual tracker time constant to the maximum tracker time constant to allow the data to enter the processor. If the data rate is too low to satisfy this ratio, the data is rejected. |
| G | DELAY DATA FREQUENCY T.C. | This is the same as Line D except that it is for the vortex delayed data. |
| H | DELAY TRACKER T.C. | This is the same as Line E except that it is for the vortex delayed data. |
| I | DELAY DATA FREQUENCY REQUIRED | This is the same as Line F except that it is for the vortex delayed data. |
| J | FRAME DURATION (MSEC) | This is self-explanatory. |
| K | STARTING FRAME NUMBER | This number determines when the trackers begin to accept new data following the start of the run. The actual time is the product of the number of frames and the frame time, where the latter is given on Line J. |
| L | L.O.S. GUARD BANDS +/+ (1.25 MSEC) | This entry sets the width of the LOS guard bands. These bands exclude vortex data in these intervals. The location of the LOS guard bands is governed by the system and is updated at the beginning of each run or every 15 seconds during non-run periods. The guard band width is twice the entry (on this line, Line L) multiplied by 0.45 milliseconds. |
| M | STARTING ALTITUDE | This number sets the altitude at which the system begins to look for the vortex. The maximum height the system can track is twice this number. |
| N | MET. ELEMENT SELECTION (E, F, L, R) | Entry of an E allows the system to select frequency and elements in the right or left configuration. Entry of an F switches only the frequency with the wind, using the configuration entered on Line O. Entry of an L or R specifies the frequency with no wind control. Whatever frequency is entered in the same column on Line S will be the receiver frequency for that side of the array entered on Line O. In this case, Column 1 should be the opposite of Column 2 (L and R, or R and L). |
| O | LOCK OUT ELEMENT SELECTION (L, R, S, C) | This entry selects the configuration when wind selection of the configuration is not used (That is, E is not used on Line N). When F is in Line N, the entry in Line O selects the configuration. Entries of L or R refer to which side the array is shifted. Note that when S (for spread) is entered, the outer six elements are used (I, II, III, VI, VII, and VIII), and when C (for compressed) is selected, the inner six elements are used (II, III, IV, V, VI, and VII). When R (for right) is selected, elements II, III, IV, VII, and VIII are used. When L (for left) is selected, elements I, II, III, V, VI, and VII are used. |
| P | WIND SWITCH POINT (+ & -) | This entry defines a value at which the array configuration or frequency shifts. The value of the entry represents the hysteresis in the wind switch action. |
| Q | L.O.S. DETERMINATION METHOD (M, T) | Two methods can be used alternatively to determine the LOS guard band locations. When M is selected, the meteorological data is entered to allow calculation of where the LOS returns should be located. If T is selected, the tracked values are used in the calculation. |
| R | PULSE LENGTH (MSEC) | This is self-explanatory. |
| S | FREQUENCY (WITH - AGAINST) WIND (HZ) | This places the received frequency in the column corresponding to the array side that should receive that frequency. Generally, the lower frequency of a two-frequency pair is received by the array side looking into the wind. |
| T | MET. DATA - WIND (FT/SEC) - REL. HUM. (%) | Column 1 contains the wind speed; Column 2 contains the relative humidity. This data is used in initializing the system for real-time or playback operation. |
| U | TEMPERATURE, PLAYBACK STARTUP | Column 1 should contain the initial temperature when beginning real-time operation. For playback, the temperature entry should represent the temperature that existed at the time the data was originally acquired. When operating in real time, an entry on Line T will update Column 2 by entering the actual outdoor temperature. During non-run periods, the temperature will be updated every 15 seconds when operating the system in real time. |
| V | DISPLAY MODE (GT-40) (VERS) | An entry in Column 1 selects the GT-40 (CRT) display. An entry in Column 2 selects the Versatec hard-copy printer/plotter. The entries are as listed below. <br><br> **GT-40** <br> An•m   Acoustogram, Array n, Receiver m <br> Tn•m   Tracking Acoustogram, Array n, Receiver m <br> Pn   Plot Display, Array n <br> Cn   Cross Plot Display, Array n <br><br> It is possible to switch back and forth between Array 1 and Array 2 for the P and C plots during and after a run, but before a new run is started. This is accomplished by depressing sequentially the SHIFT and 8 keys on the keyboard unit for array 1, and by depressing sequentially the SHIFT and 9 keys on the keyboard unit for array 2. <br><br> **Versatec** <br> Pn   Plot Printout, Array n where n may be 1, 2, or B (for both) <br> An•m   Acoustogram Printout, Array n, Receiver m, m may be any number for one acoustogram, any three numbers for three acoustograms, or A for all six acoustograms. |
| W | CONSTANT PATH LENGTH - DATE | The constant path length entry takes into account the distance from the antenna reflector to the actual receiver location. A typical entry for Column 1 is 5 (for five feet). Column 2 should contain the day-of-the-year information. |
| X | AIRPORT CODE - TAPE NUMBER | The entry in Column 1 should be a letter chosen to represent the airport at which the data was acquired, such as K for J. F. Kennedy International Airport. The entry in Column 2 is used to assign a number to the magnetic tape of the data acquired. |

**Page 2**

The element positions on Page 2 are the locations of the center of the reflector. The distances are as measured from the extension of the runway centerline. Positive numbers are used to designate distances to the right of a pilot landing on the runway; negative numbers are used to designate distances to his left.

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entering an E in Line B, Column 1, Page 1. The analog recorded
control signals will then automatically govern system operation.
In addition, the EOS (Start) and EOL (Stop) keys on the keyboard
unit can be used, in conjunction with the key-operated Power
switch on the GT-40, to remotely start and stop, respectively,
the analog recorder.

If data recorded on another system is to be played back (the so-
called Q-playback mode), a Q must be entered on Page 1, Line A,
Column 1, of the processing parameters. The procedure then is
the same as for P-playback except that all entries on both pages
of the processing parameters are required. The start-of-run
time that will be displayed will be the playback start time, not the
time at which the recorded run actually started.

Digital tapes may be played back to obtain CRT display or to 'dump'
data on the Versatec. Such playback requires loading a different
program into the computer. The following approach is used.
Place the system into operation by repeating Steps 1. through 17.
(Section 2.2.1). In Step 18., set switch 1 at the ONE (Up) position.
Place all the remaining ADDRESS/DATA switches at the ZERO
(Normal) position. Continue with Step 19. Remove the program
tape from the TU-10. Load the data tape to be dumped into the
TU-10.

If only a CRT display is desired, set either SWR switch 0 (for
Array 1) or switch 1 (for Array 2) at the ONE (Up) position to
select the array whose associated data is to be dumped. Set
switch 15 to the ONE (Up) position and the header of the first run
on the tape should be displayed.

If a Versatec printout is desired, before setting switch 15 at the
ZERO (Down) position, set switch 14 to the ONE (Up) position for
Versatec printout and then set SWR switch 15 to the ZERO (Down)
position. A page at a time can be printed out by appropriate
operation of switch 15. If switches 14 and 13 are both set at the
ONE (Up) position, prior to setting switch 15 to the ZERO (Down)
position, setting of switch 15 to ZERO will result in a continuous
printout of sequential pages until the end of the digital tape.

### 2.3.4 Changing System Run Counter

The CTRL (Control) key and either the A (for add) key or the S
(for subtract) key (all on the keyboard unit) can be used to incre-
ment or decrement, respectively, the number in the system run
counter. This can be done regardless of whether the system is
operating in real time or playing back data recorded on another
system (Q playback) since it permits correct run numbers to be
assigned to the data being printed out or displayed. During play-
back of data recorded on this system (P-playback) the run number
is read directly from the analog magnetic tape.

### 2.3.5 Operating Summary

The following is a brief review of the operating procedures des-
cribed in detail in preceding paragraphs of this section.

1. Power up the system

2. Load the program tape into the digital recorder

3. Load the program into the minicomputer

4. Place fresh digital tape on the digital recorder

5. Place fresh tape, if needed, in the analog recorder

6. Operate as described above by using the keyboard unit
   functions listed on Table 2-4, or operate under external
   automatic control.

TABLE 2-4   Keyboard Functions

| Key or Keys | Description | Function |
|---|---|---|
| ↑ | Up Arrow | Start Run |
| ↓ | Down Arrow | Stop Run |
| ← | Left Arrow | Start LOS Track |
| → | Right Arrow | Stop LOS Track |
| EOS LOCK | | Start Acoustic Transmission or Analog Recorder |
| EOL LOCK | | Stop Acoustic Transmission or Analog Recorder |
| HOME | | Ready for Run |
| CTRL @ | Control At | Display Parameter List |
| SHIFT 1 | | Page 1 Request |
| CTRL R | | Re-define LOS Zones and Update Wind Values |
| CTRL A | | Increment Run Number |
| CTRL S | | Decrement Run Number |
| CTRL D | | Parameter Printout |
| SHIFT 8 | | Display Array 1 (GT-40) |
| SHIFT 9 | | Display Array 2 (GT-40) |

# 3. SOFTWARE DOCUMENTATION

## 3.1 INTRODUCTION

The software documentation package, together with the program magnetic tape itself, provides a complete and usable record of the PAVSS operating system.

The program listing consists of a complete set of listings of all the main programs and subroutines in the operating system. These routines and programs are all written in Avco Modular Test System (AVMOTS) assembly language which is similar to DEC PAL II language. The AVMOTS program is a cross-assembler and linkage editor that runs on the IBM 360 computer. The input medium is punched cards; the output is a magnetic tape that can be directly loaded into the system. Within the program, any symbolic references to locations defined in another program and contained by that program are resolved by the AVMOTS linkage editor. As noted in Paragraph 3.2, the program listing is provided under separate cover.

The software description consists of a general outline of the functional purpose, structure, and method of operating system and its major subroutines. This description is contained in Paragraph 3.3 of this report.

## 3.2 PROGRAM LISTINGS OF THE PAVSS OPERATING SYSTEM

The program listing is provided under separate cover due to its size and magnitude.

## 3.3 SOFTWARE DESCRIPTION

### 3.3.1 General

The software system is required to perform three functions: PAVSS operation, PAVSS control, and data processing. The system consists of an operating system/application program. All programs are initially loaded into the PDP-11 from a 7-track tape, using a bootstrap loader.

The operating system permits the operator to initialize the sys-
tem by prompting him for various parameter values. The GT-40
display screen (CRT) and its associated keyboard are used for all
operator/system communication. Other portions of the operating
system allow the operator to start and stop a run and to supply
the radar subsystem controller with the parameters needed for
signal processing. Other functions of the operating system
include:

- Power Fail and Restart Handling

- Interrupt Processing, including interrupts from the:

    Operator (Keyboard)

    Radar Subsystem Controller

    Hard-Copy Printer

    Digital (7-Track) Magnetic Tape Recorder

    Clock

- I/O Processing, including formatting and control
  routines for the:

    Keyboard

    GT-40 CRT Display

    Hard-Copy Printer

    Digital (7-Track) Magnetic Tape Recorder

- Conversion, including routines for converting from:

    ASCII to Binary

    Binary to ASCII

    Binary to BCD

3-2

Based on the operator's choice, the operating system provides the parameters required or allows the operator to alter them. Upon completion of processing, the system checks to see if any operator's requests are outstanding, honors valid requests, and repeats the cycle until the operator stops the run, or 200 seconds have elapsed.

### 3.3.2 Operating System

The following descriptions and flow diagrams present a general outline of the PAVSS software. It is intended to be an overview of the software system operation. In several cases, considerable detail is presented in the flow diagrams when it is felt that this could aid the operator in understanding his control of the system. Other large sections of the computer program, or code, are described only by the function that they perform without reference to the method used in performing them. Still other lower level "service" routines, such as the floating point routine, are not described at all.

The complete software system is defined by the program listing-- which, as noted in Paragraph 3.2, is submitted under separate cover since it is too voluminous to be physically a part of the final report. These routines and programs are all written in AVMOTS assembly language, a language quite similar to DEC PAL II language. Within a program, any symbolic references to locations defined in another program and contained by that program are resolved by the AVMOTS linkage editor. This represents a very powerful tool and it has been used extensively.

Although the flow charts shown in Figures 3-1 through 3-5 are intended to be self-explanatory, a short description is provided to assist in understanding the connections between various routines.

A flow chart of the main program is shown in Figure 3-1. This chart shows very little program detail, with large portions indicated only by their function. Examples are: Perform Requested Software Change, Do Delay Tracking, etc.
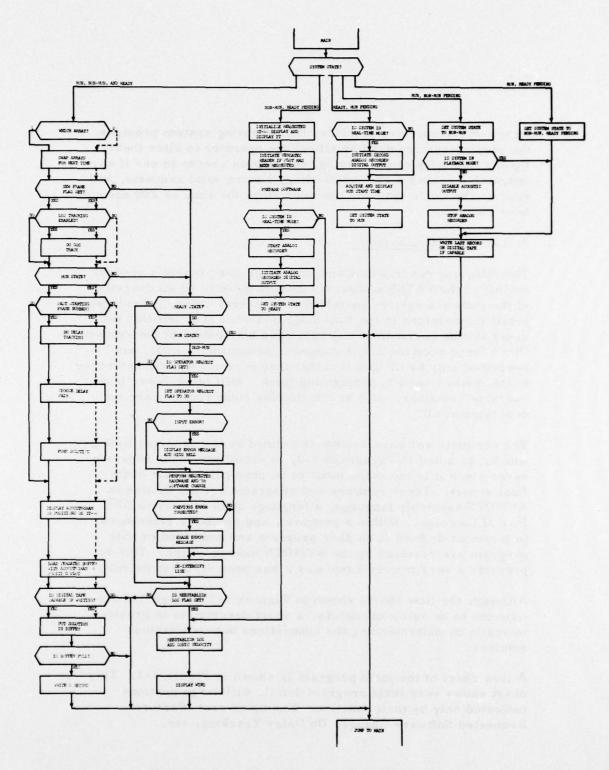
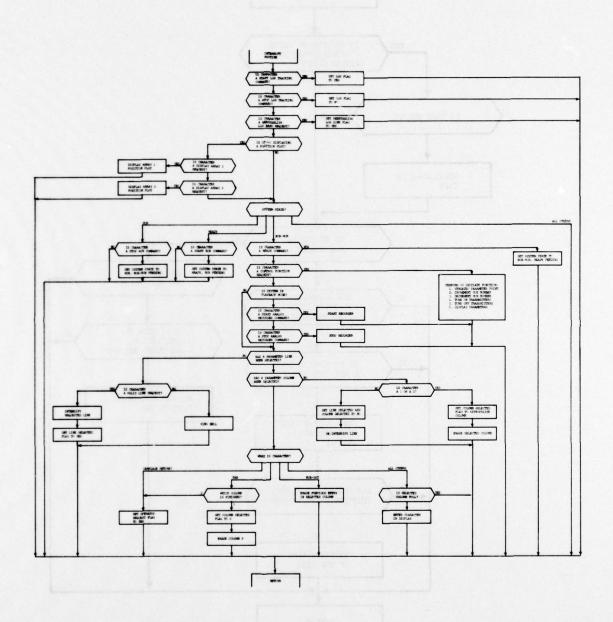FIGURE 3-1 Flow Chart, MAIN Program
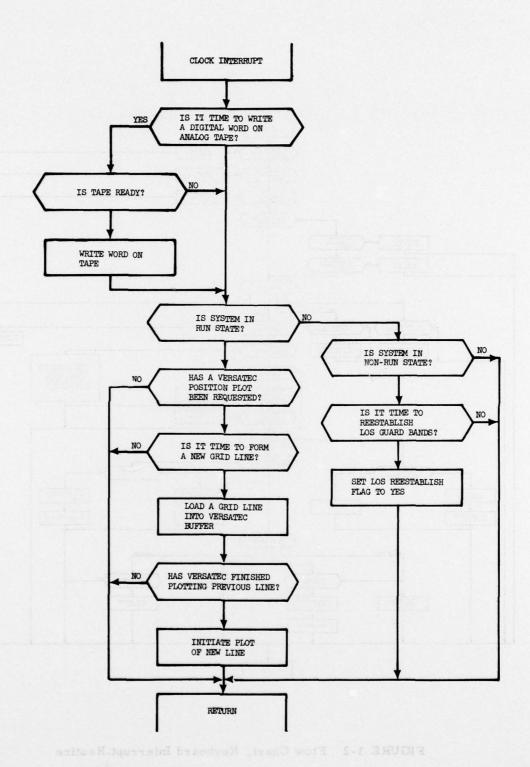
3-4

**FIGURE 3-2   Flow Chart, Keyboard Interrupt Routine**

3-5

CLOCK INTERRUPT

IS IT TIME TO WRITE A DIGITAL WORD ON ANALOG TAPE?   YES

IS TAPE READY?   NO

WRITE WORD ON TAPE

IS SYSTEM IN RUN STATE?   NO

IS SYSTEM IN NON-RUN STATE?   NO

HAS A VERSATEC POSITION PLOT BEEN REQUESTED?   NO

IS IT TIME TO REESTABLISH LOS GUARD BANDS?   NO

IS IT TIME TO FORM A NEW GRID LINE?   NO

SET LOS REESTABLISH FLAG TO YES

LOAD A GRID LINE INTO VERSATEC BUFFER

HAS VERSATEC FINISHED PLOTTING PREVIOUS LINE?   NO

INITIATE PLOT OF NEW LINE

RETURN

FIGURE 3-2   Flow Chart, Keyboard Interrupt Routine
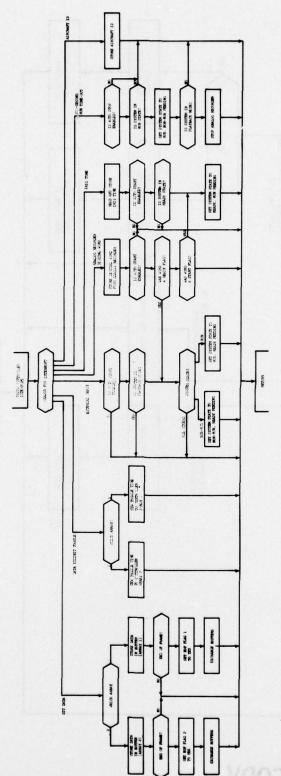
FIGURE 3-3   Flow Chart, Clock Interrupt Routine

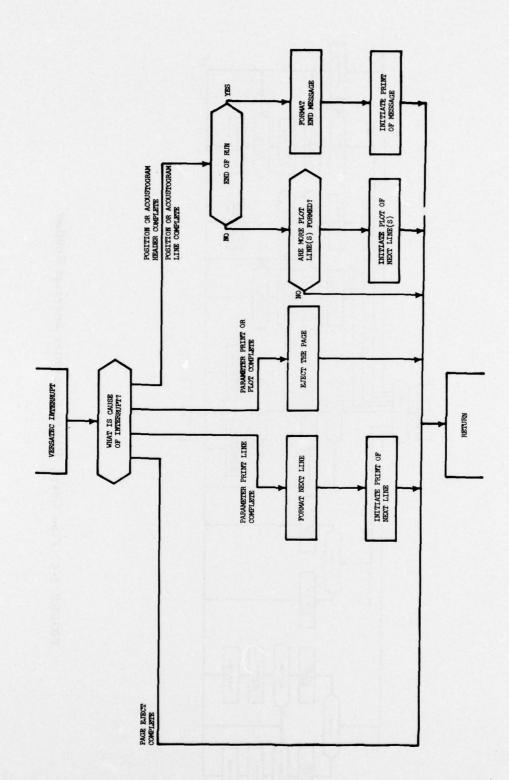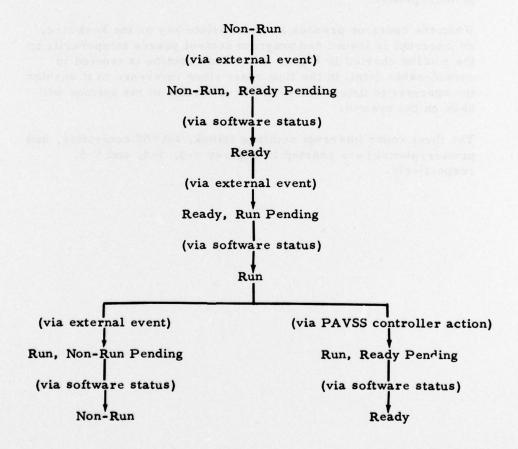FIGURE 3-4 Flow Chart, PAVSS Controller Interrupt Routine

FIGURE 3-5  Flow Chart, Printer/Plotter (Versatec)
Interrupt Routine

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The chief flow routing parameter in MAIN is called the system
state.  Its value is determined by either the status of the software
or external events.  The events may be operator actions or signals
sent to the PAVSS controller.  The normal transition route of the
system state is as follows:

Non-Run

(via external event)

Non-Run,  Ready Pending

(via software status)

Ready

(via external event)

Ready,  Run Pending

(via software status)

Run

| (via external event) | (via PAVSS controller action) |
|---|---|
| Run, Non-Run Pending | Run,  Ready Pending |
| (via software status) | (via software status) |
| Non-Run | Ready |

The only exit from the loops of MAIN is by a hardware/software
action called an interrupt. When an interrupt is issued, the
program status is stored and control is transfered to the appro-
priate interrupt routine. When the interrupt routine has finished,
the pre-interrupt program status is restored and control passes
back to the interrupted routine. Using this method, various para-
meters in the MAIN program (such as system state) may be
changed. Four devices are capable of issuing interrupts: the
keyboard, the PAVSS controller, the clock, and the hard-copy
printer/plotter.

When the operator presses an appropriate key on the keyboard,
an interrupt is issued and program control passes temporarily to
the routine charted in Figure 3-2. This routine is treated in
considerable detail in the flow chart since reference to it enables
the operator to determine what effect certain of his actions will
have on the system.

The three other interrupt routines (clock, PAVSS controller, and
printer/plotter) are charted in Figures 3-3, 3-4, and 3-5,
respectively.

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